Appendix C
Major Unit Process Capability Evaluation
Performance Potential Graph Spreadsheet Tool
for the Partnership for Safe Water

Section 1 - Background on the Major Unit Process Capability Evaluation

Water treatment plants are designed to take a raw water source of variable quality and produce a consistent, high quality finished water using multiple treatment processes in series to remove turbidity and prevent microbial contaminants from entering the finished water. Each treatment process represents a barrier to prevent the passage of microbial contaminants and particulates in the plant. By providing multiple barriers, any microorganisms passing one unit process can possibly be removed in the next, minimizing the likelihood of microorganisms passing through the entire treatment system and surviving in water supplied to the public.

The performance potential graph (see Figures C-1 and C-2) is used to characterize capabilities of individual treatment processes to continuously function as a barrier for removing particulates and harmful pathogens. Each of the major unit processes is assessed with respect to its capability to consistently contribute to an overall plant treated water quality of less than 0.1 NTU turbidity during peak flows. Specific considerations are given only to process basin size and capability under optimum conditions. Limitations in process capability due to minor deficiencies or incorrect operation (e.g., degraded baffles which allow short-circuiting or improper process control) do not contribute to development of the performance potential graph. These operational or minor modification limitations are addressed during the evaluation of the other aspects of the treatment plant conducted as part of the Partnership for Safe Water self-assessment procedures.

Specific performance goals for the flocculation, sedimentation, filtration, and disinfection unit processes are used when developing the performance potential graph. These include settled water turbidities of less than 2 NTU and filtered effluent turbidities of less than 0.1 NTU. Capabilities of the disinfection process are assessed based on the CT values outlined in a USEPA guidance manual for meeting filtration and disinfection requirements. Rated capacities are determined for each of the unit processes based on industry standard loading rates and detention times with demonstrated capability to achieve specific unit process performance goals. These evaluation criteria are defined in Table C-2 of this appendix. The resulting unit process rated capacities are compared to the peak instantaneous operating flow for the treatment plant. Any unit process rated capacities which do not exceed the plant's peak instantaneous operating flow are suspect in their ability to consistently meet desired performance goals that will maximize protection against the passage of microbial contaminants through the treatment plant. Specific interpretation of the results of the performance potential graph are discussed in Section 3 of the Partnership for Safe Water self-assessment procedures. It is important that the

Figure C-1. Example performance potential graph spreadsheet output for LOTUS 123 releases.

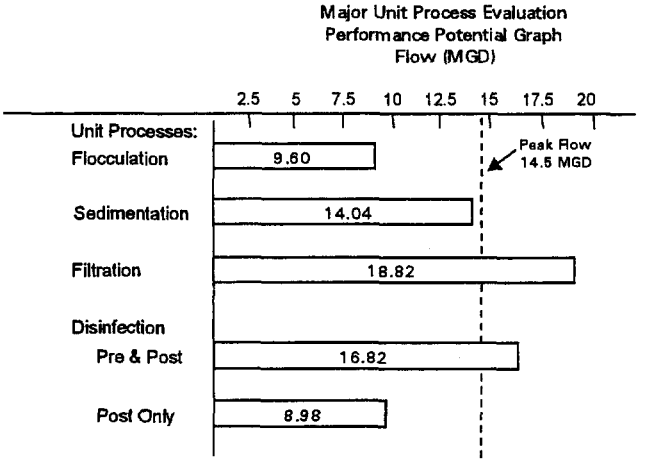
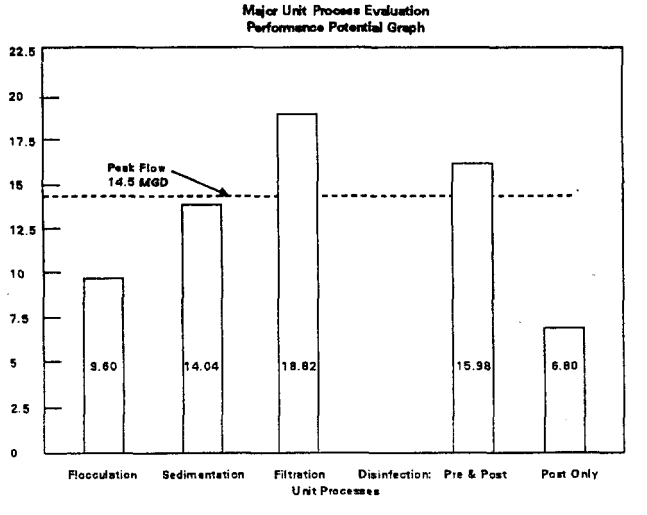


Figure C-2. Example performance potential graph spreadsheet output for EXCEL and QUATTRO PRO releases.



evaluator recognize that the guidance provided by this computer software should not exceed the evaluators' judgement in projecting unit process capability. Options to change loading rate projections to values different from those provided are available and should be considered if data or the evaluators' experience justifies the modification.

Section 2 - The Performance Potential Graph Spreadsheet Tool

Spreadsheets have been generated to assist Utility Partners in creating the performance potential graph required for Section 3 for use in the Partnership for Safe Water self-assessment procedures. Generating the performance potential graph requires opening the appropriate spreadsheet file and entering specific physical plant information in the defined cells (see Figure C-4). A performance potential graph will be generated automatically. Rated capacities for each unit process are generated from user-defined criteria as well as from criteria defined in Table C-2 and discussed in Section 3 of the Partnership for Safe Water self-assessment procedures. The user may print a hard copy of the performance potential graph by following steps defined in Section 6 of this appendix.

Users requiring expanded instructions for entering appropriate information in the spreadsheet cells should refer to Figure C-3. Should users require additional assistance in preparing a performance potential graph using the spreadsheet, please contact Eric Bissonette of USEPA/OGWDW Technical Support Division at (513) 569-7933.

Section 3 - Selecting the Appropriate Spreadsheet for Your Application

Performance Potential Graph Spreadsheets have been developed in LOTUS 123 Release 2.4 for DOS and 5.0 for WINDOWS, EXCEL Release 4.0 and 5.0 for WINDOWS, and QUATTRO PRO Release 5.0 for WINDOWS software systems. Select the files corresponding to your application and data entry needs from Table C-1 and proceed to Section 4.

Table C-1. File Designations for Various Software Spreadsheets - Performance Potential Graph

	for DOS	for WINDOWS		
Performance Potential Graphs	LOTUS 123 2.4	LOTUS 123 5.0	EXCEL 4.0 or 5.0	QUATTRO PRO 5.0
Working Files	PPG.WK1	PPG.WK4	PPGXLC-XLS	PPGQP.WB1
External Format Files	PPG.FMT	None	None	None

Section 4 - Loading the Spreadsheet

- Copy the required working file and external format file from the Master Diskette to a directory resident on the hard drive of your computer. Do NOT work from the files contained on the Master Diskette.

- Enter your spreadsheet software by selecting the appropriate icon or menu option (e.g., click on the LOTUS 123 Release 5.0 icon). (Note: WYSIWYG needs to be invoked for the LOTUS 123 Release 2.4 spreadsheets.)

- Open the working file as specified in Section 3 and save the file under a new file name.

Section 5 - Entering Plant Information

Each spreadsheet contains a data entry section and a chart which depicts the resulting individual unit process rated capacities. The LOTUS 123 spreadsheets generate a performance potential graph with the unit process rated capacities characterized by horizontal bars (see Figure C-1). Contrarily, the EXCEL and QUATTRO PRO performance potential graphs characterize the unit process capacities by vertical bars (see Figure C-2). The data entry sections are identical for the LOTUS 123, EXCEL, and QUATTRO PRO performance potential graph files (see Figure C-3).

- Begin entering appropriate physical plant data in cells B31..B71 and E32..E69. Figure C-4 contains in-depth description of the acceptable entries for each of the cells in the spreadsheet.

- The entered physical plant data will appear in blue. Cells containing black values are calculated from data entered in other cells and cannot be modified.

Figure C-3. Performance potential graph data entry guide.

Peak Instantaneous Flow	What is the peak flow in MGD at any instant through the treatment plant? This peak flow is based on historical records and pumping capacity. (See Section 3 of the Self-Assessment for further discussion.)

Predisinfection

Presedimentation	Does the plant have and utilize a presedimentation basin? Enter Yes or No.
Presed. Basin Volume	What is the volume (in gallons) of the presedimentation basin(s)?
Presed. Basin Baffling	What is the baffling condition of the presedimentation basin(s)? Unbaffled Poor Average Superior impacts effective volume calculation regarding predisinfection contact time based on estimated T_{10} to T ratios.
Predisinfection Practiced	Does the plant apply a disinfectant prior to the clearwell? Enter Yes or No.
Temperature (°C)	What is the coldest water temperature (in degrees Celsius) at the predisinfectant application point?
pH	What is the maximum pH at the predisinfectant application point?
Predisinf. Residual (mg/L)	What is the maximum predisinfectant residual (in mg/L)?
Predisinf. Application Point	Where is the predisinfectant applied? Prior to the presedimentation or flocculation or sedimentation or filtration unit processes?
Required CT	Using the predisinfection operating conditions (pH and Temp and required log removals), obtain the required CT value from Appendix C of the Surface Water Treatment Rule Guidance Manual or Appendix A of the CCP Handbook.
Predisinfection Volume	Calculated from data entered in other areas. No entry is required here.
Effective Predisinf. Volume	Calculated from data entered in other areas. Incorporates effective contact of the disinfectant based on baffling in each of the unit processes.

Flocculation

Basin Volume	What is the total volume (in gallons) of the flocculation basin(s)?
Temperature (°C)	What is the coldest water temperature (in Celsius) that the flocculation basin experiences?
Mixing Stages	Describe the stages contained within the flocculation basin(s). Single or Multiple? No baffling or interbasin compartments equals single-staged. All other conditions equal multiple-staged.
Detention Time	
Suggested	Suggested detention time calculated using above information from existing conditions (see Attachment 2). No entry is required here.
Assigned	Enter a detention time (in minutes). Use the suggested detention time or select one based on site-specific circumstances.
Rated Capacity	This is the rated capacity of the unit process (in MGD) calculated from the Assigned hydraulic detention time. No entry is required here.

Sedimentation

Basin Volume	This volume is calculated from other entered data. No entry is required here.
Surface Area	What is the total area (in square feet) of the sedimentation basin(s)?
Basin Depth	What is the average depth (in feet) of the sedimentation basin(s)?
Operation Mode	Enter Turbidity or Softening, depending on the process used. Is the process operated mainly to remove turbidity or to provide softening?
Process Type	What settling process is utilized? Enter Rectangular/Circular/Contact/Lamella Plates/Adsorption Clarifier or SuperPulsator.
Tubes Present	What type of settling tubes is present in the sedimentation basin(s)? Enter None or Vertical (>45°) or Horizontal (<45°).

Figure C-3. Performance potential graph data entry guide (continued).

	Process SOR	
Suggested		Suggested surface overflow rate calculated using above information from existing conditions (see Attachment 2). No entry is required here.
Assigned		Enter a surface overflow rate (SOR) (in gpm/ft^2). Use the suggested SOR or select one based on site-specific circumstances.
Rated Capacity		This is the rated capacity of the unit process (in MGD) calculated from the Assigned surface overflow rate. No entry is required.

Filtration

Total Filter Surface Area		What is the total surface area (in square feet) of the filter(s)?
Total Number of Filters		What is the total number of filters in the treatment plant?
Filters Typically in Service		What number of filters are typically in service?
Total Volume Above Filters		What is the total volume of water above the filter media (in gallons)?
Media Type		What media configuration is present in the filters? Enter Sand, Dual, Mixed, Deep Bed.
Operation Mode		How are the filters operated? Enter Conventional Direct, Inline Direct.
Raw Turbidity		What is the yearly 95th percentile raw water turbidity value? Refer to the raw water turbidity spreadsheet output table.
Air Binding		What level of air binding is noticeable in the filter(s)? Enter None, Moderate, High.

	Loading Rate	
Suggested		Suggested filter loading rate calculated using above information from existing conditions (see Attachment 2). No entry is required here.
Assigned		Enter a filter loading rate (in gpm/ft^2). Use the suggested rate or select one based on site-specific circumstances.
Rated Capacity		This is the rated capacity of the unit process (in MGD) calculated from the Assigned filter loading rate. No entry is required here.

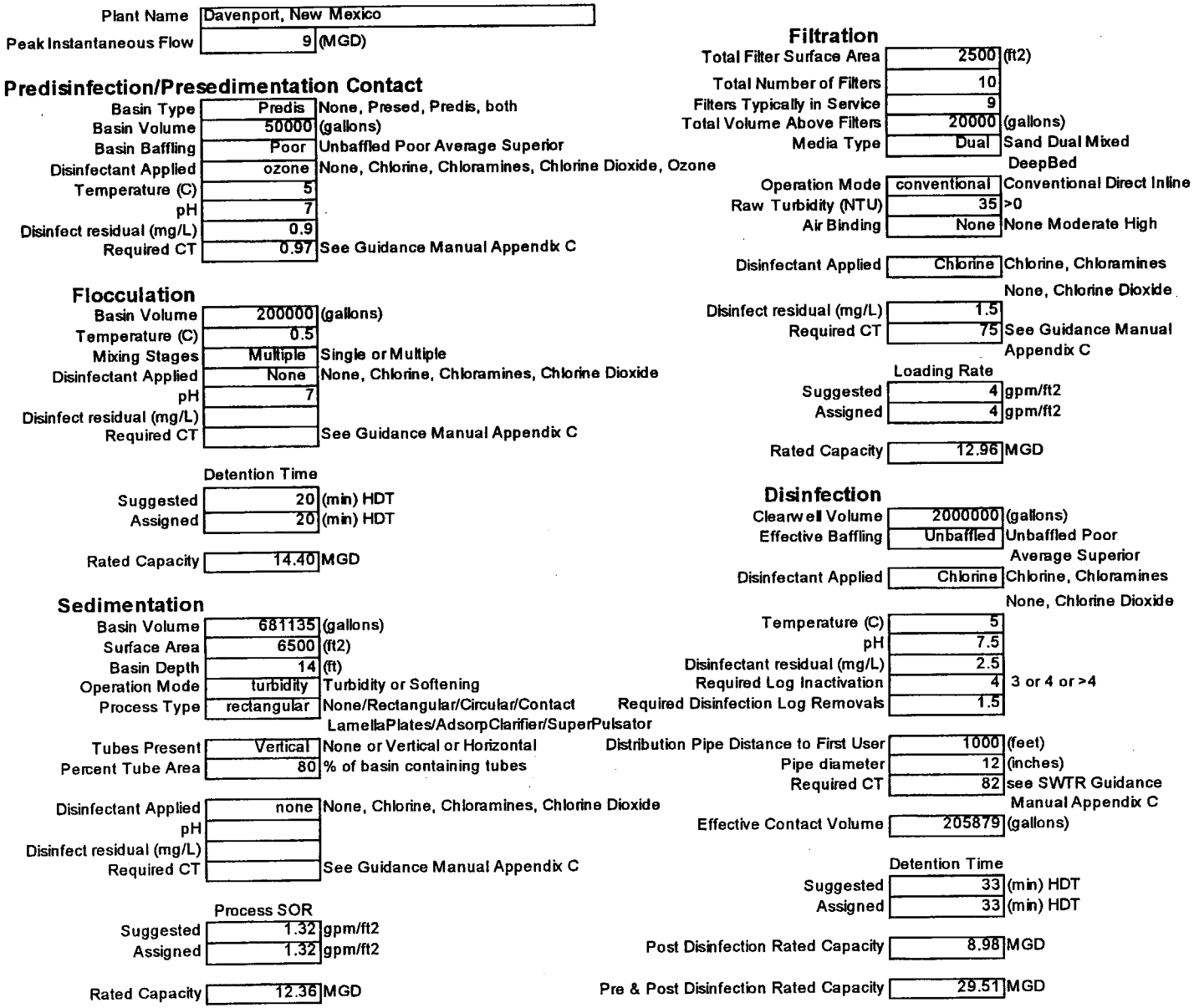
Disinfection

Clearwell Volume		What is the total volume (in gallons) of the clearwell(s)?
Effective Baffling		What is the baffling condition of the clearwell(s)? Enter Unbaffled, Poor, Average, Superior. Impacts effective volume calculation regarding disinfection contact time.
Temperature (°C)		What is the temperature (in degrees Celsius) at the disinfectant application point?
pH		What is the pH at the disinfectant application point?
Disinfectant Residual (mg/L)		What is the maximum disinfectant residual (in mg/L)?
Required Log Inactivation		Enter the total number of log removals required for the plant. Enter 3 or 4 or >4 (must be a numeric value).
Reqd. Disinfection Log Inactivation		Required disinfection log removals calculated from other data. No entry is required here.
Pipe Distance to First User		What is the transmission distance (in feet) to the first user/customer?
Pipe Diameter		What is the pipe diameter (in inches) of the transmission pipe?

Figure C-3. Performance potential graph data entry guide (continued).

Required CT		Using the disinfection operating conditions (pH and Temp and required log removals), obtain the required CT value from Appendix C of the Surface Water Treatment Rule Guidance Manual or Appendix A of the Composite Correction Program Handbook.
Effective Contact Volume		Calculated from data entered in other areas. No entry is required here.
Detention Time		
Suggested		Suggested detention time calculated using above information from existing conditions (see Attachment 2). No entry is required here.
Assigned		Enter a detention time (in minutes). Use the suggested detention time or select one based on site-specific circumstances.
Post Disinfection Rated Capacity		This is the rated capacity of the unit process (in MGD) calculated from the Assigned detention time and required CTs. No entry is required here.
Pre & Post Disinf. Rated Capacity		This is the rated capacity of the unit process (in MGD) calculated from the Assigned detention time and required CTs. No entry is required here.

Figure C-4. Example performance potential graph data entry section.



Plant Name: Davenport, New Mexico
Peak Instantaneous Flow: 9 (MGD)

Predisinfection/Presedimentation Contact

Basin Type	Predis	None, Presed, Predis, both
Basin Volume	50000	(gallons)
Basin Baffling	Poor	Unbaffled Poor Average Superior
Disinfectant Applied	ozone	None, Chlorine, Chloramines, Chlorine Dioxide, Ozone
Temperature (C)	5	
pH	7	
Disinfect residual (mg/L)	0.9	
Required CT	0.97	See Guidance Manual Appendix C

Flocculation

Basin Volume	200000	(gallons)
Temperature (C)	0.5	
Mixing Stages	Multiple	Single or Multiple
Disinfectant Applied	None	None, Chlorine, Chloramines, Chlorine Dioxide
pH	7	
Disinfect residual (mg/L)		
Required CT		See Guidance Manual Appendix C

Detention Time

Suggested	20	(min) HDT
Assigned	20	(min) HDT

Rated Capacity: 14.40 MGD

Sedimentation

Basin Volume	681135	(gallons)
Surface Area	6500	(ft2)
Basin Depth	14	(ft)
Operation Mode	turbidity	Turbidity or Softening
Process Type	rectangular	None/Rectangular/Circular/Contact LamellaPlates/AdsorpClarifier/SuperPulsator
Tubes Present	Vertical	None or Vertical or Horizontal
Percent Tube Area	80	% of basin containing tubes
Disinfectant Applied	none	None, Chlorine, Chloramines, Chlorine Dioxide
pH		
Disinfect residual (mg/L)		
Required CT		See Guidance Manual Appendix C

Process SOR

Suggested	1.32	gpm/ft2
Assigned	1.32	gpm/ft2

Rated Capacity: 12.36 MGD

Filtration

Total Filter Surface Area	2500	(ft2)
Total Number of Filters	10	
Filters Typically in Service	9	
Total Volume Above Filters	20000	(gallons)
Media Type	Dual	Sand Dual Mixed DeepBed
Operation Mode	conventional	Conventional Direct Inline
Raw Turbidity (NTU)	35	>0
Air Binding	None	None Moderate High
Disinfectant Applied	Chlorine	Chlorine, Chloramines None, Chlorine Dioxide
Disinfect residual (mg/L)	1.5	
Required CT	75	See Guidance Manual Appendix C

Loading Rate

Suggested	4	gpm/ft2
Assigned	4	gpm/ft2

Rated Capacity: 12.96 MGD

Disinfection

Clearwell Volume	2000000	(gallons)
Effective Baffling	Unbaffled	Unbaffled Poor Average Superior
Disinfectant Applied	Chlorine	Chlorine, Chloramines None, Chlorine Dioxide
Temperature (C)	5	
pH	7.5	
Disinfectant residual (mg/L)	2.5	
Required Log Inactivation	4	3 or 4 or >4
Required Disinfection Log Removals	1.5	
Distribution Pipe Distance to First User	1000	(feet)
Pipe diameter	12	(inches)
Required CT	82	see SWTR Guidance Manual Appendix C
Effective Contact Volume	205879	(gallons)

Detention Time

Suggested	33	(min) HDT
Assigned	33	(min) HDT

Post Disinfection Rated Capacity: 8.98 MGD

Pre & Post Disinfection Rated Capacity: 29.51 MGD

Table C-2. Major Unit Process Evaluation Criteria*

Flocculation		Hydraulic Detention Time
Base		20 minutes
Single Stage	Temp $\leq$ 0.5°C	+10 minutes
	Temp >0.5°C	+5 minutes
Multiple Stages	Temp $\leq$ 0.5°C	+0 minutes
	Temp >0.5°C	-5 minutes

Filtration	Air Binding	Loading Rate
Sand Media	None	2.0 gpm/ft²
	Moderate	1.5 gpm/ft²
	High	1.0 gpm/ft²
Dual/Mixed Media	None	4.0 gpm/ft²
	Moderate	3.0 gpm/ft²
	High	2.0 gpm/ft²
Deep Bed	None	6.0 gpm/ft²
	Moderate	4.5 gpm/ft²
	High	3.0 gpm/ft²

Sedimentation		Surface Overflow Rate
Rectangular/Circular/Contact	Basin Depth	
Turbidity Mode	> 14 ft	0.7 gpm/ft²
	12 - 14 ft	0.6 gpm/ft²
	10 - 12 ft	0.5 - 0.6 gpm/ft²
	<10 ft	0.1 - 0.5 gpm/ft²
Softening Mode	> 14 ft	1.0 gpm/ft²
	12 - 14 ft	0.75 gpm/ft²
	10 - 12 ft	0.5 - 0.75 gpm/ft²
	<10 ft	0.1 - 0.5 gpm/ft²
Vertical (>45°) Tube Settlers		
Turbidity Mode	> 14 ft	2.0 gpm/ft²
	12 - 14 ft	1.5 gpm/ft²
	10 - 12 ft	1.0 - 1.5 gpm/ft²
	<10 ft	0.2 - 1.0 gpm/ft²
Softening Mode	> 14 ft	2.5 gpm/ft²
	12 - 14 ft	2.0 gpm/ft²
	10 - 12 ft	1.5 - 2.0 gpm/ft²
	<10 ft	0.7 - 1.5 gpm/ft²
Horizontal (<45°) Tube Settlers		2.0 gpm/ft²
Adsorption Clarifier		9.0 gpm/ft²
Lamella Plates		4.0 gpm/ft²
SuperPulsator		1.5 gpm/ft²
with tubes		1.7 gpm/ft²
Claricone Turbidity Mode		1.0 gpm/ft²
Claricone Softening Mode		1.5 gpm/ft²

*If long term (12-month) data monitoring indicates capability to meet performance goals at higher loading rates, then these rates can be used.

Renner, R.C., B.A. Hegg. J.H. Bender, and E.M. Bissonette. 1991. Handbook - Optimizing Water Treatment Plant Performance Using the Composite Correction Program: EPA 625/9-91/027. Cincinnati, OH: USEPA.

AWWARF Workshop. 1995. Plant Optimization Workshop. Colorado Springs, CO: AWWARF.

Eastern Research Group. Inc. 1992. Water Advisor Utilizing the CCP Approach [Expert System). USEPA Work Assignment No. 7391-55. Eastern Research Group, Inc., Arlington, MA.

USEPA, AWWA, AWWARF, Association of Metropolitan Water Agencies, Association of State Drinking Water Administrators. and National Association of Water Companies. 1995. Partnership for Safe Water Voluntary Water Treatment Plant Performance Improvement Program.

- Each major unit process section contains a suggested and assigned evaluation criteria cell (e.g., the flocculation section contains a suggested and an assigned hydraulic detention time cell). The suggested loading rates, summarized in Table C-2 of this appendix, for specified situations are representative of conditions in which identified unit processes have demonstrated effectiveness in serving as a multiple barrier in the prevention of cyst and microorganism passage through the treatment plant.

- The actual rated capacities for each of the unit processes are calculated from the loading rates entered into the cells labeled "assigned loading rates." Users must enter a value into the assigned cell, either selecting the "suggested" value or entering their own loading rate.

- The performance potential graph contained at the top of each spreadsheet will instantaneously update after each data entry. Complete the entire data entry process prior to proceeding to printing the spreadsheet output described in Section 6.

Section 6 - Printing Spreadsheet Output

To print the performance potential graph using:

- LOTUS 123 Release 2.4 for DOS, invoke the WYSIWYG add-in and print the previously defined range by pressing <Shift :> then selecting <Print> and <Go> after the system has been configured to the user's printer. If the WYSIWYG add-in is unavailable, users should generate and print the graph PIC file PPG.PIC, using the LOTUS Printgraph procedures.

- LOTUS 123 Release 5.0 for WINDOWS, or QUATTRO PRO Release 5.0 for WINDOWS, or EXCEL Release 4.0 or 5.0 for WINDOWS, follow printing techniques specified for WINDOWS applications by clicking on a printer icon (which will print the previously defined range) or select PRINT from the File submenu (and select "previously defined range" when the system requests a printing option). Users may have to adjust margins to accommodate individual applications in order to print output to a single sheet of paper.

Section 7 - Important Rules to Remember When Using the Performance Potential Graph Spreadsheet Tool

- Cells containing "Black" values are calculated from other pertinent data entries and cannot be modified because the cells have been protected.

- The actual rated capacities for each of the unit processes are calculated from the loading rate entered into the cells labeled "assigned loading rates." Users must enter a value into the assigned cell, either selecting the "suggested" value or entering their own loading rate.

- The external format file must be copied from the Master Diskette to the same directory as the working file or the Performance Potential Graph will not be visible when using LOTUS 123 Release 2.4 for DOS.